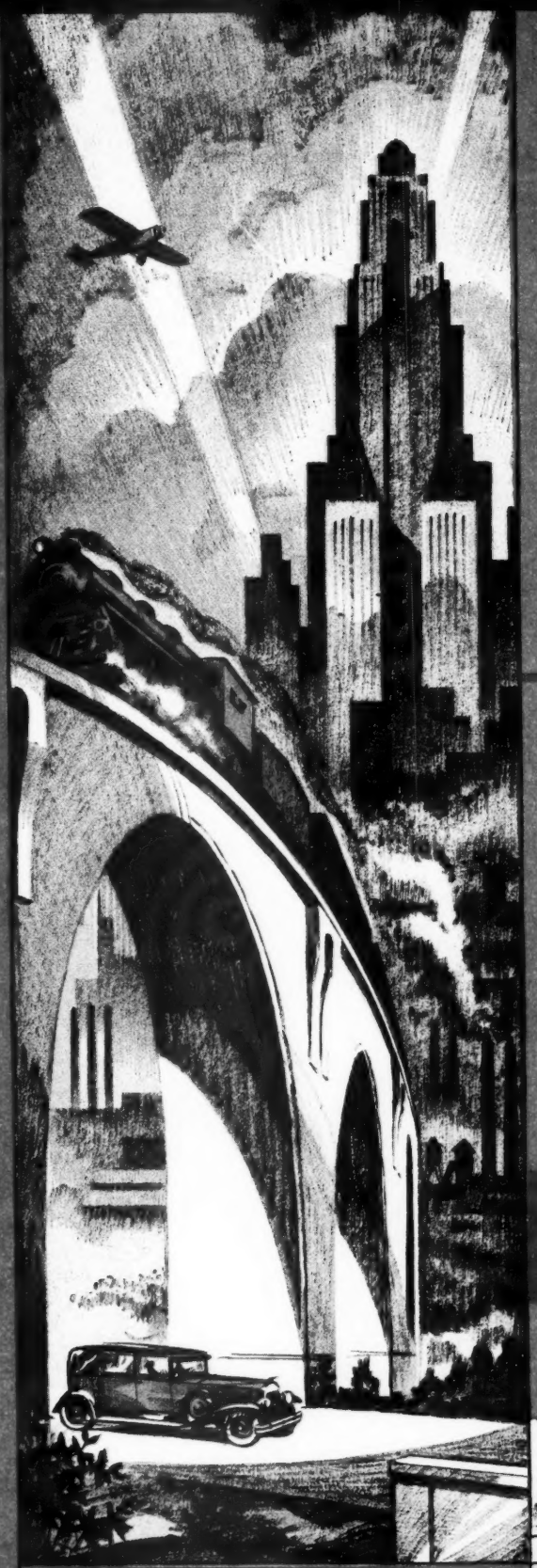
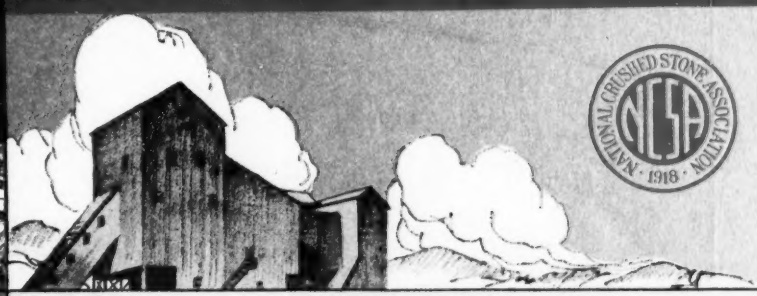


The CRUSHED STONE JOURNAL

In This Issue

- Concrete Construction for Outlet Works, Denison Dam, Texas
- A Rational Approach to the Secondary Road Problem
- The Importance of Research to the Crushed Stone Industry
- Are We Progressing Fast Enough in the Defense Effort

SILVER ANNIVERSARY



May—June • 1941

Official Publication
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of the

National Crushed Stone Association, Inc.

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BULLETIN No. 1

The Bulking of Sand and Its Effect on Concrete

BULLETIN No. 2

Low Cost Improvement of Earth Roads with Crushed Stone

BULLETIN No. 3

The Water-Ratio Specification for Concrete and Its Limitations

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The Bituminous Macadam Pavement

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The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

J. R. BOYD, Editor

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1918-1942

SILVER ANNIVERSARY CONVENTION

THE NEXT ANNUAL CONVENTION of our industry will be a milestone of special significance—marking the 25th Anniversary of the establishment of the National Crushed Stone Association. By no other means than through this organization would it have been possible to attain the teamwork, group effort, and solidarity so indispensable today to industrial and individual welfare.

The coming convention will be more than a celebration of the Association's Silver Anniversary. It will be much more, too, than the usual annual meeting to take stock of the year's activities and to lay plans for the next. It will be an extra-special, sterling event you will long remember.

Details will follow later. The main suggestion now is that you grasp the extraordinary character of the coming convention, and pledge yourself to be present.

THE CRUSHED STONE JOURNAL

WASHINGTON, D. C.

Vol. XVI No. 3 MAY-JUNE, 1941

Cincinnati Selected for Twenty-fifth Anniversary Convention

WHEN crushed stone producers foregather next year from all sections of the country to meet in annual convention, this event will have noteworthy significance for it will be the occasion for celebrating the 25th Anniversary of the establishment of the National Crushed Stone Association. This milestone, so outstanding in the history of our industry and the organization which represents it, demands the unusual and plans are now being formulated to make this meeting equal in every way to the inspiring occasion which it will commemorate.

Basic to the success of any convention is, of course, the matter of attendance and this important factor is dependent in large measure upon the selection of a suitable location, bearing in mind also the parallel requirement of a hotel with adequate facilities to properly accommodate both the convention and the Manufacturers' Division exposition. It was with these considerations in mind, supplemented by the knowledge obtained from past experience of the excellent location and admirable convention facilities enjoyed by the Netherland Plaza Hotel in Cincinnati, that the Board of Directors, at its meeting following the annual convention last January, took action as expressed in the following motion:

> "That the matter of selecting the date and place for the annual convention in 1942 be referred to the Executive Committee with power to act, it being the position of the Board that the Netherland Plaza Hotel in Cincinnati be chosen if suitable arrangements can be made."

As a result of this action by the Board of Directors, it became the responsibility of the Executive Committee to make final determination as to the time and place for the 25th Annual Convention.

No difficulty was encountered by the Executive Committee at its meeting in Washington, on March 20, 1941, in making appropriate arrangements with the Netherland Plaza Hotel in accord with the Board's suggestion, but when it came to the question of dates, possible conflict with other organizations presented a real problem. Originally expecting to hold the convention during the week of January 19, it was a keen disappointment to learn that because of circumstances beyond control, the Road Show of the American Road Builders' Association, instead of being scheduled for the week of January 26, as was most desired, had to be shifted to the week of January 19. As for obvious reasons it would be highly undesirable for us to conflict with the Road Show, we were faced with the necessity of selecting dates either before or after the week of January 19.

In view of these considerations and after consultation with other interested groups it was decided to hold our 25th Anniversary Convention on February 2, 3, and 4, and possibly on the 5th should circumstances make the addition of the extra day desirable—and, as was previously indicated, at the Netherland Plaza Hotel in Cincinnati.

It is our understanding that the annual conventions of the National Sand and Gravel Association powers, but they must do this by a margin sufficient to eat into and overcome the head start that Germany and her allies have achieved. By the most conservative of estimates, Germany, before we entered seriously into war preparation, had accumu-

(*Continued on page 16*)

Concrete Construction for Outlet Works, Denison Dam, Texas[1]

By A. M. PHILLEO

Concrete Technician and Resident Engineer, Denison Dam, U. S. Engineer Office, War Dept., Denison, Texas

• **Excellent results were obtained with the use of crushed stone in the construction of the Outlet Works of the Denison Dam and it should be of interest to crushed stone producers to know something of the properties of the aggregates and the resulting concrete.**

THE design of concrete mixes for the concrete used in the outlet works of the Denison Dam and Reservoir Project, has developed no major problem. The selection of aggregates has been largely a matter of elimination rather than a matter of choice. The cement used is cement manufactured under specifications for Moderate Heat of Hardening Cement with some minor modifications. The excellence of both the concrete and the finish thus far attained are the results of rigid control rather than any abracadabra or magic formula developed in the mix itself.

The Denison Dam and Reservoir Project will control the runoff from approximately 38,000 square miles of drainage area on the Red River. The dam is located some five miles northwest of the city of Denison, Texas, and is 751 miles above the mouth of the Red River. At the dam site, the river flows nearly due east, the Oklahoma and Texas abutments of the dam being designated as the north and south abutments respectively. The principal features of the dam are the rolled-earth embankment, the concrete spillway, and the outlet works.

The outlet works are on the south side of the river and occupy the space between the south bank and the south abutment. They consist essentially of an intake tower, eight conduits, and a stilling basin. Though the three main features of the outlet works are being constructed concurrently, they will be described and dealt with separately. The intake consists of a paved approach channel with guide walls, the maximum height of which is 35 feet. The intake tower, which contains the gates, rises 131 feet above the rock foundation, and is surmounted by a deck which carries the gantry crane and other gate operating mechanism. Stairways and an elevator afford means of communication between the various levels in the tower. The transition section is also part of the intake. This portion of the intake is 32 feet in length and its function is to transform each water passage from two rectangular chambers to the circular passage of the conduit. Of the eight conduits, three are devoted to flood control and five to power use. The flood control conduits are the three adjacent to the river. They are approximately 800 feet in length, 20 feet in diameter and are unlined. The five power conduits vary in length from 800 feet to 840 feet, are twenty feet in diameter and are lined with ½ inch steel plate liners. Between conduits 4 and 5 there is an access gallery 6′ x 20′. This gallery connects with the stairwell and elevator shaft at the intake tower, and with a transverse gallery in the portal wall at its downstream end. The stilling basin consists of two pools, each pool containing two rows of baffles, and the two pools are separated by a weir. The flow through the stilling basis is further restricted by walls on each side of the pools. The above description briefly outlines the principal features of the outlet works, which embrace approximately a quarter of a million cubic yards of concrete.

Six months before the aggregate contracts were advertised, an intensive study of material sources was made. This study covered the area within a circle whose radius was 100 miles and included some 80 properties in 50 different localities in two states. The properties investigated were both operating properties and potential sources. These properties fell under four general headings: sand and gravel deposits, gravel deposits, sand deposits and rock outcrops. The first two were largely confined to deposits along the Arkansas, the Washita and the Trinity rivers in Oklahoma and Texas. Local sand deposits were found to be adequate both as to quality and quantity. Rock outcrops are fairly evenly distributed over the area. The products of the operating properties producing crushed rock come largely from the Goodland limestone formation, the Viola limestone formation and the Bromide limestone formation. In the fold of the Arbuckle uplift, the Viola limestone and a formation known as Talihina Chert

[1] Presented at the Twenty-Fourth Annual Convention of the National Crushed Stone Association, Cincinnati, Ohio, January 20-22, 1941.

are often found contiguous in the same quarry. The potential sources of rock are Arbuckle limestone and granite.

Samples were obtained from all properties investigated. These samples in practically all cases approximated one ton. Preliminary tests on these aggregates included, sodium sulphate (five cycles), freezing and thawing (100 cycles), and Los Angeles wear tests. Mechanical analyses of the coarse aggregates were made on a Ty-Lab Tester and of the sand on a Ro-Tap. Both the mechanical analyses and the unit weights were the composites of a number of tests.

On December 5, 1939, bids for furnishing approximately 320,000 tons of crushed stone or washed gravel, and 150,000 tons of washed sand were opened. The Southwest Stone Company of Dallas, Texas and Julian C. Field Company of Denison, Texas, were the successful bidders for furnishing crushed stone and washed sand respectively. Contracts with these firms were entered into a few days later. The program of investigation was now widened and a series of mixes was initiated. Samples from these mixes were subjected to the following tests: freezing and thawing (100 cycles), tests in flexure, compressive tests and wear tests. The mix which developed the most favorable characteristics under all of the above tests was one having a cement factor of 3¾ sacks per cubic yard and a water-cement ratio represented by 7¼ gallons of water per sack. However, as practically all of the concrete in the outlet works may be classed as reinforced concrete, this mix did not develop the required mobility. The mix finally used was one having a cement factor of 4 sacks per cubic yard and a water-cement ratio represented by 7 gallons of water per sack of cement.

The choice of what appears to be a rather low cement factor was not dictated wholly as a matter of economy. Tests indicated that concrete having a cement factor around 4 sacks per cubic yard and a water-cement ratio represented by 7 to 7¼ gallons of water per sack of cement developed much higher resistance to wear than concretes with higher cement factors, and that this concrete, when placed against steel forms, gave a much denser texture and developed fewer air and water pockets. Since the concrete in the water passages in the intake, the unlined flood conduits and the stilling basin will be subjected to flows of high velocities, and since smooth surfaces are not only desirable but esesntial, the choice of the mix becomes quite obvious.

Grading studies and laboratory experiments indicated that so long as the aggregates were graded and proportioned in such a manner that particle interference was not developed between any two sizes, mobility of the mix could easily be maintained. This has required rigid inspection at the producers' plants, but results have warranted this phase of field control.

The contractor's material handling equipment and mixing and placing equipment are adequate. Cement is received in bulk and is transferred to a 2500 barrel steel silo at the mixing plant, by compressed air. Coarse aggregates are delivered in two sizes, viz., 2″ to 1″ and 1″ to No. 4. This material is shipped from the plant at Stringtown, Oklahoma, in 70 ton bottom dump steel gondolas. Sand is delivered by trucks from the local plant. All aggregates are dumped into a "boot" from which they are transferred to storage bins above a reclaiming tunnel by a belt conveyor and shuttle conveyor. The capacities of these storage bins are 2500 tons each. From the reclaiming tunnnel the aggregates are transported to the mixer bins by another belt conveyor. Batching equipment is automatic and electrically operated. After some minor adjustments, this equipment has given a very satisfactory performance. Two 2 cubic yard concentric zone mixers of the tilting type comprise the mixing equipment. These mixers dump into a collecting hopper. The transporting and placing system consists of a cableway and a four cubic yard bottom dump bucket which can be spotted over practically all features of the work. At the intake tower this cableway is supplemented by a traveling crane which handles a two cubic yard bottom dump bucket. Final placement is accomplished by the use of internal vibrators.

All water passages in the intake and flood conduits have been formed against steel forms. The resulting surfaces have been uniformly good. "Buck shot," "Bug holes" and similar surface defects have been held to a minimum. Where vertical surfaces have been sand blasted, distribution of aggregates throughout the lifts, regardless of thickness, is extremely uniform. This is also evidenced on horizontal surfaces that have been "cut" with an air and water jet preparatory to receiving succeeding lifts.

The entire intake structure is divided into two monoliths, separated by a contraction joint at the center. After completion of the structure it is the intention that the two monoliths act independently as continuous, self-contained structures. The structure has been further divided into blocks and closure sections and a program of placement scheduled to gain the maximum benefits from this type of construction. The foundations and invert placements for the flood conduits were laid out in checker board pattern. The same pattern was followed in placing the foundations

under the power conduit liners. Web placements, covering four conduits each are placed above the foundation and invert blocks. These web placements carry the concrete to within a couple of feet of the crown of the conduits. The conduits are completed by the third and last placement in the form of cover blocks, the pattern of which again assumes the checker board design. This arrangement of placements provides ample time for the dissipation of heat without retarding placing progress. The use of blocks and closure sections in the stilling basin, including the walls, has maintained progress and yet facilitated heat dissipation.

Concrete thus far placed has been very satisfactory both as to surface texture and compressive strengths developed. Considering the formed areas, surface patching has been negligible. Longitudinal joints at the inverts and circumferential joints in the flood conduits have not always been all that could be desired, and have, in places, required some grinding and patching. Surfaces of the concrete thus far placed in the weir, baffles, and walls of the stilling basin are exceptionally free from defects. This applies to both vertical and sloping faces.

The coarse aggregate deserves mention here. The quarry from which it is produced is one of the quarries in the fold of the Arbuckle uplift, and the product is Viola Limestone and Talihina Chert. This combination produces an extremely hard, angular product, the predominating constituent of which is calcium carbonate (approximately 95 per cent). The hardness of the rock is between six and seven, as measured by Moh's scale of geological hardness. This material is dry-screened and is exceptionally clean when loaded. Mixing valves which permit close and accurate grading are provided at the loading chutes. This is not only convenient but necessary as the grading of this material must be kept within very definite limits. During transporting and handling, this rock tends to segregate and requires close inspection, particularly at the mixing plant, where workability must be maintained by rather exacting changes and shifts in aggregate quantities, which is just another way of saying that particle interference must be reduced to and maintained at a minimum. Concrete embodying this rock as aggregate, is both tenacious and mobile when properly handled. Such mixes, however, are not responsive to a change in moisture content and workability must be secured as outlined above.

With rigid field control, at the producing plants, at the mixing plant, and at the forms, 160,000 cubic yards of very good concrete has been placed to date. Compressive strengths have been consistent, aggregate distribution has been uniform throughout the lifts, and surfaces have been exceptionally free from defects.

Adequate Motor Transport Is Vital to Army

POINTING out that in the conquest of France and the Low Countries all German supplies were carried by motor, Brig. Gen. J. E. Barzynski of the U. S. Quartermaster Corps at the annual convention of the National Automotive Dealers Association in Pittsburgh emphasized the important role that motor transportation will play in the national defense program.

"A fast and reliable system of motor movement was a vitally important factor in the German conquest," he said. "Activity in the repairs of wrecked railroads was not even attempted during the early stages of this conflict. Without motor vehicles carrying troops and supplies, the word blitzkreig would hardly have its present meaning in the world today."

Campaigns, he asserted, are being fought and won in Europe and the Near East by the extensive use of motor transportation to facilitate rapid movement of troops and their timely supply of ammunition and food.

That the motor vehicle has replaced the famous army mule was indicated by Gen. Barzynski, who asserted that the field army of 1,400,000 men would need approximately 250,000 vehicles, that today there are 70,000 motor vehicles in service and by the latter part of April, there will be 140,000, and by the end of the fiscal year 190,000, representing an increase of almost seventeen times the number of motor vehicles in army service four years ago.

"We can no longer remain on hard surfaced roads," he said. "Our trucks must be able to go across country, negotiating all kinds of terrain, wherever our combat troops and artillery may be located."

Simplification of army requirements was also stressed by the speaker. He urged that modifications of standard commercial vehicles be limited to those that can be made without unduly retarding production. The highest aim of standardization being the greatest degree of interchangeability.

A Rational Approach to the Secondary Road Problem[1]

By EDWARD H. NUNN
Construction Engineer,
Maryland State Roads Commission

• **The present article by E. H. Nunn is a thoughtful description of his methods for building low maintenance cost secondary roads. Highway engineers should read this common sense article and stone producers, too, for it shows how very effective is one of their products, stone screenings, for subgrade stabilization and for base and surface construction.**

DURING the past decade, much effort has been directed toward improvement of the tertiary or "farm-to-market" road systems. Various schemes have been propounded for building "bargain roads" and the low cost road theme song has been sung loud and long. Unfortunately, experience now shows that the verse of this song is followed by a chorus of sour notes—a medley of mounting maintenance costs. It's the old story of the white elephant with the tremendous appetite.

The Maryland State Roads Commission, like most other states, has experimented with various cheap improvement methods. We, too, have built roads at costs that ran only a little way into four figures. But no more—not after we learned the answer to the simple question, "What price low-cost?", as revealed in our maintenance figures on the cheap experimental roads.

Brushing aside promises incapable of fulfillment and recognizing that we get only what we pay for, we have gone back to fundamentals. Any type of road placed on a given subgrade and subject to given traffic and weather conditions, requires a definite minimum in strength and thickness of base and wearing surface. To try to beat this fact, we have concluded, is folly. Our objective now is to provide tertiary roads with a surface adequate to give year-round service with an absolute minimum of maintenance. We are convinced that such construction is not only less expensive in the long run but, with reduction of maintenance interruptions, is most satisfactory from the standpoint of service to motorists.

Faced with the upkeep of 4,300 miles of roads on the State system and 11,000 miles of County roads, the Maryland Roads Commission is also confronted with a wide range of temperatures, humidities and altitudes. While relatively small in total area (12,327 square miles), the state boundaries are extremely irregular, a width of less than 2 miles separating the borders of West Virginia and Pennsylvania at one point. Usually looked upon as a seaboard state, it may be surprising to some to learn that Oakland, Md., is located further west than Buffalo, N. Y. Sea level elevations vary from 9 feet on

[1] Reprinted from *Earth Mover and Road Builder.*

The Maryland State Roads Commission finds that investment in calcium chloride stabilized bases, as shown above, is good economy. Less thickness is required for bituminous surfaces, like one shown at left, and maintenance costs are minimized.

the eastern short to 3,081 feet in the western part of the state, and there are three definite geological formations—Coastal Plain, Piedmont Plateau, Appalachian Range. All of these factors have a definite bearing on our tertiary roads problem, for subgrade conditions and available native soils are equally varied in different sections. The sum total of all

Sinepuxent Road, Worcester County, Md., stabilized with stone screenings and calcium chloride in 1940 and carried as an open surface through the winter. Illustration shows road as photographed March 13, 1941, before spring maintenance. Materials are tightly compacted with no signs of rutting or ravelling.

factors must be taken into consideration in effecting satisfactory road improvement, so our job is to find the best possible combination.

Acting upon the precept that no road surface is better than its foundation, attention is first directed toward the subgrade and base. Here we have found the principles of soil-stabilization of utmost value—and have developed means of applying these principles to all of the different conditions encountered.

Soils Investigations

When a tertiary road has been selected for improvement, our Soils Division steps in and makes a complete analysis of the soil to determine its bearing value and what combination of local materials will be necessary to obtain a satisfactory surface. Then they recommend a procedure for stabilizing this base and design a suitable soil-mixture. The mixture is designed to produce the maximum density possible within economical limits and must, of course, be related to the availability of local soils and aggregates. Quality is not sacrificed for expediency, however, and it is sometimes necessary to haul materials a considerable distance to assure satisfactory mixes.

Depending, then, upon the original soils analyses, plus conditions of temperature, humidity and traffic, the stabilizing procedure falls broadly into one of three classifications:

(1) Placement of a mat of granular materials, such as stone or slag screenings, on native soils lacking these frictional materials.

(2) Construction of stabilized soil-aggregate surface courses on native soil subgrades.

(3) Addition of clay to predominantly sand surfaces, or addition of sand to predominantly clay surfaces.

To keep this article within reasonable length limits, no attempt will be made to cover all three of the stabilizing procedures. Selecting one method as an example, however, our specifications for Stabilized Soil Base Course, under the classification designated as (1) above, are as follows:

Description

This item shall consist of a temporary wearing surface of stone or slag screenings placed on a com-

Dun Swamp Road, Worcester County, Md. A 4-inch compacted base of calcium chloride stabilized stone screenings was constructed in 1939 and a surface bituminous treatment made in 1940. Original soil survey showed an exceptionally poor subgrade, and the highway department had many misgivings concerning success of this project. Despite swampy conditions along entire length of road, inspection in March, 1941, revealed that the surface has remained in perfect shape.

pleted subgrade or base in accordance with the special provisions and in conformity with the cross sections shown on the plans.

Materials

(a) The screenings to be used as stabilization course shall be prepared from clean, tough, durable, crushed rock or slag complying with the following gradation: 90-100 per cent passing ½ inch, 10-30 per cent passing No. 100 sieve. (Hardness by Los Angeles Abrasion Test—Maximum loss of 50 per cent.)

(b) Calcium Chloride. Shall conform to the A. S. T. M. Specifications D-98-34.

Construction Methods

1. After the subgrade has been properly shaped and compacted, the screenings as above described shall be spread uniformly over the entire subgrade area to the depth as shown by the typical cross section of improvement. The screenings shall be compacted by sprinkling, if necessary, and rolling with a ten-ton power roller. (From 2 inches to 6 inches compacted depth is provided, dependent upon the subgrade condition revealed in the soils investigation.)

2. When the work on the project has progressed to a point which will permit traffic to use the surfacing, it will be permitted to do so, thus assisting in the binding of the stabilization course. During the compacting period, which will not be less than two

Calcium chloride was used to stabilize the base materials before bituminous cover was placed on approximately 36 miles of shoulders along Maryland Route No. 2, during 1938 and 1939. Photo shown here was taken on April 14, 1941 and is typical of the excellent conditions maintained.

weeks, the road shall be kept accurately shaped with a road machine to prevent the formation of ruts, so that at the end of this period, the uniform, well-bound surface of the cross section shown on the plans will be produced. Further rolling during this two-weeks period may be required.

3. Any spots where the material does not bind properly or where the subgrade is spongy and mixes with the screenings in such a way as to form muddy places, additional screenings shall be placed with or without the removal of the underlying material as may be directed by the Engineer, and the surface compacted.

Same soil materials were used for base stabilization of 16 miles of shoulders along Maryland Route No. 2, but without chemical treatment. This photo shows how bituminous surface has failed despite constant maintenance. See accompanying picture of shoulders where base was treated with calcium chloride.

4. Application of Calcium Chloride. As soon as the stabilization course has been completed for a distance of 2,000 feet, calcium chloride shall be applied at the rate of one pound per square yard. The calcium chloride shall be applied to the surface in flake form, and to a width as indicated on the plan. As soon as the entire roadway has been completed, another application at the same rate shall be applied to the roadway, thus making a total of two (2) pounds per square yard of calcium chloride for the finished roadway. A period of at least two (2) weeks shall elapse between the first and second application of calcium chloride.

Proper Drainage

Since, in a stabilized mixture, the finer particles of soil are used as binder for the coarser particles, adequate surface drainage is essential—to prevent any "washing out" of the fine soil particles during periods of rain. Our construction contracts specify that the cross slope of the roadway must be sufficiently inclined from center to shoulder to provide free run-off of rain water. The slope is never less than ¼ inch per foot of road width and is sometimes

as much as ½ inch per foot of width. Under maintenance this A-type crown is carefully preserved to avoid potholing and consequent destruction of the designed gradation.

Moisture Control

During the period when stabilized roads are undergoing compaction, the maintenance of a near optimum moisture content is of vital importance. Maximum densities can be most economically obtained—with minimum expenditure for labor and equipment—through the use of calcium chloride. As will be noted in the foregoing specifications, the chemical is applied immediately following construction and a total of 2 pounds per square yard is used in two applications. On those of our jobs completed in the spring or early summer, no further application is necessary prior to the surface oil treatment in the fall.

In keeping stabilized roads sufficiently moist to hold the soil particles firmly in place, calcium chloride prevents disintegration and preserves the original depth of stabilization until such time as the bituminous treatment is made. The road remains dustless under traffic and only occasional maintenance-blading is required for surface smoothness.

When stabilized bases are completed in the fall, they are maintained throughout the winter as open surfaces and in the spring, before the natural moisture leaves the road, an additional application of calcium chloride is made. Instead of increasing the cost of the road, this treatment actually reduces the ultimate cost since it eliminates the expenses otherwise incurred through loss of materials and excessive blading prior to bituminous treatment. We have found that it is false economy to delay calcium chloride application in the hope that rains will occur on a time-table schedule.

A good example of the economics of stabilized construction is offered in a road located in Wicomico County on the eastern shore, and known as Allen's Ferry Road. This 2.2 mile section was stabilized in 1935 by placing a 6-inch compacted layer of stone screenings over the native soil subgrade. Calcium chloride was applied immediately after construction and further applications were made annually until the road was bituminous-surfaced in 1940. Measurement of depth and gradation analysis of this section showed no appreciable change since its stabilization five years previous, and the bituminous treatment was made without addition of any new base materials. Maintenance of the stabilized section had been very nominal and our cost records for the two fiscal years previous to bituminous surfacing shows a total of only $376.89: Labor and Equipment $109.06, Calcium Chloride $267.83.

We have written the use of a moisture-retention agent into our specifications and have made it a part of our construction contracts because we feel its value far exceeds its cost. Considering that the expenditure for the chemical represents only about 2 per cent of the total cost of stabilization, we deem it an extremely reasonable means of protecting our construction investment by preserving the base course and insuring success of the bituminous surface.

Bituminous Surfacing

In line with our opinion that the lowest cost road is really the road that permits year-round traffic—year after year—with minimum interruption for maintenance, we place a bituminous surface on our stabilized bases as rapidly as conditions permit.

This bituminous surface treatment consists of two ½ gal. applications of bituminous material. A prime coat of MC-1 or RT-1 or 2 is applied and covered with 20 lbs. of ¾ chips or pit run gravel. The seal coat is ½ gal. RC-2 or 3. (The RC-2 in cool weather; the RC-3 in warm or hot weather.) The seal is covered with 25 to 30 lbs. of ¾ chips. Both cover courses are rolled and the final course broom-dragged as well as rolled. The treatment costs from 12c to 18c per sq. yd., depending upon length of haul for both bituminous material and the cover. Where pit run gravel is used the cost is some 8c to 9c per sq. yd.

Recent Tests

In early April of this year (1941), our Soils Division took sample cores of the stabilized bases on several of our projects. All of the sections tested had been open to traffic as stabilized surfaces prior to bituminous treatment, and we were desirous of comparing their present mechanical analysis and physical characteristics with the original mixture design used when constructed. The test results revealed that, in every instance where calcium chloride had been used, the material in place prior to bituminous surfacing has remained within desirable limits, and there has been no appreciable loss of depth in the stabilized base courses under traffic. That the moisture-retention agent has performed its function is, thus, proved conclusively. The following examples are typical of the test results:

(*Continued on page 17*)

The Importance of Research to the Crushed Stone Industry[1]

By ROY W. CRUM

Director, Highway Research Board, Washington, D. C.

• **No one is better qualified than is Mr. Crum to speak informatively and with authority on the subject of this article. Because of his long experience in the highway research field his observations and suggestions should carry great weight. Crushed stone producers will distinctly profit from a careful reading of his discussion.**

AT THE turn of the nineteenth century, a hundred and forty years ago, roads, although the only means of land transport were a horror to the traveler. Blanketed with dust in dry weather, sunk to the hubs in wet weather and ever in danger of highway robbery, any one to travel at all must face an ordeal not to be lightly undertaken. Only the very rich could manage it in safety and a slight degree of comfort.

In the transition from this condition to the serviceable turnpike that came into being in the early eighteen hundreds a researching Scot, to whom the crushed stone industry owes a large debt of gratitude, had a large part. His research work had such a profound and lasting effect that his name has become a common noun in the English and American languages.

One must admit that this is a rare distinction. Many mediocre men get their names before the world in capitals, but you must do something of real value to the human race to live on in small letters. So put John Loudon Macadam on the roll of fame—along with that other great Scotchman McIntosh.

Crushed stone had been used in road work before Macadam's time. In fact there were layers of crushed stone in the better Roman roads, and on the continent it was used in much the same way that Macadam used it. Perhaps he got his idea there.

There were many things that Macadam did not know and some that he did know were not so, but he studied and experimented and arrived at a conception of the use of crushed stone as an individualistic material having characteristic properties of its own that are valuable in road work, whereas in its earlier uses it was thought of as bulk filler only.

Of course some of the ideas he had were wrong, but anyway he must have arrived at them by some variety of the process we know as research.

Is research of value to the crushed stone industry? I should say that is a silly question; if it were not for research there would be no crushed stone industry. But then, that is a perfectly general statement we can apply to all industry. I expect the development of the first stone ax which could be produced in quantity at a profit was the result of several thousand years of experimentation. Any industry that does not do research or contribute to research is getting a free ride. That can be said with good grace here because the crushed stone industry is recognized by engineers as a leader in its field of research.

But if I am to make that assertion stick I must explain my conception of research. It is not just a matter of test tubes, testing machines and laboratories. The laboratory is a useful research tool and that is all. Research goes much beyond that, and it is not easy to define it in a word or phrase or sentence.

One popular definition is that research consists in digging some facts out of one obscure place and putting them into another.

The way you pronounce the word is one clue to the kind of researcher you are. If you say re-search', that is pretty highbrow stuff, but if you say re'-search, that is mostly the kind that engineers and stone producers do. However, the basic fundamental research of the physical scientist is important to your industry, for the application work of engineering research must follow basic scientific principles.

To me any study that tends to bring out previously unknown facts, interpret them, and apply them to the benefit of mankind is research. In other words it is any studious inquiry that extends the knowledge of the worker. One pretty good dictionary definition is "diligent investigation to discover facts by study." A thorough study of all available existing information bearing on a problem is research.

So you see, by this concept, all industrial progress is through research and we must admit that if the crushed stone industry has developed and become profitable, research must have played an important part in the process.

[1] Presented at the Twenty-Fourth Annual Convention of the National Crushed Stone Association, Cincinnati, Ohio, January 20-22, 1941.

But we might ask, whose research, ours or that of some outside agency through which we have fortuitously received some benefit?

Since 1920 the use of crushed stone on highways has been multiplied about four times in volume and three times in value of products. (See Table 1)

TABLE 1

	Tons	Value	Average price per ton
1919	27,000,000	$30,500,000	$1.14
1939	97,000,000	$89,000,000	$0.95

What caused this growth? During this same time, road building and motor vehicle transportation expanded enormously. Perhaps the crushed stone industry just went along and grew with the market. But the research factor was there just the same. What caused the increased public demand for more and more good roads? Wasn't it because of the fact that through research the automotive engineers were continually producing better vehicles at less cost?

That expansion in road work gave crushed stone its opportunity, but there must also have been research work of a high order on the problems of road materials, design and construction that enabled the industry to make good on that opportunity and expand in a highly competitive world.

It may be interesting to review briefly a few of the important research results of that period which have affected the development of the crushed stone industry.

Prior to this era the prevailing practice of specifying concrete mixtures by arbitrary loose volumes of aggregates gave very indefinite results in terms of the strength and durability of concrete and in many cases gave crushed stone a handicap in competition with other materials. All the engineers had to go on in specifying proportions was the fact that on some other occasion a certain loose volume arrangement had given (so far as they could tell) satisfactory results.

With the enunciation of the water-cement ratio principle by Abrams, we had definite knowledge of the controlling factors as respects strength, and with the demonstration of the practicability of specifying mixtures by absolute volumes or by weights, and the practicability of weighing the cement and the aggregates and of close measurement of the water, we acquired control of the economic factors. So now we can proportion mixtures and put them together in certain knowledge of their strength and the costs of the ingredients.

New uses have been found for crushed rock products. Stone sand is now recognized as a useful material, whereas at one time it was not considered usable at all. To bring this about wasn't just a matter of proving its value. Considerable research went into finding out how to produce stone sand which does have useful properties, and into finding how to use it to the best advantage.

Much has been learned about the effects of gradation of crushed stone particles on portland cement and bituminous mixtures for various purposes; from strength of concrete to skid resistance of bituminous surfaces. The work of the National Crushed Stone Association laboratory with its circular track has contributed important findings in this respect.

Another important study in connection with this circular track has been on the control of the effects of water on bituminous pavements. These effects may be pretty bad at times.

Much research effort has been devoted to the development of test methods and standard specifications. I can think of nothing of more importance to a producer than having available accurate and generally accepted tests by which the quality of his material can be proved beyond dispute.

But these things we have been talking of are in the past. Perhaps the job is done, and we can ease off on research work.—Well, here is what an English contemporary said recently about bituminous roads.

"The seekers of the perfect bituminous road have a more difficult job than their colleagues working on (portland cement) concrete. There is only one binding agent in concrete and it behaves according to well-established rules which are relatively so simple that even engineers are beginning to understand them. Bituminous binders are legion; they are composed of obscure hydro carbons with sesquipedalian names and their behavior, if not entirely unpredictable is at least variable enough to add a spice of adventure to those who are trying to unravel the mysteries. Apparently to prevent the thing from becoming too easy, moreover, the workers in different laboratories have allowed a state of complete chaos to arise in the methods by which the various materials are tested and identified."

And here is what a distinguished American investigator has to say about concrete:

"Considering its weight, its compressive strength is low; its very low tensile strength cannot be utilized even in reinforced concrete design; it is not impervious to moisture; it shrinks upon drying; it contains soluble compounds which are removed by the leaching action of water; its insulation value as regards

transfer of heat and transfer of sound is not high. On every hand we see examples of its faulty performance. Buildings and pavements are badly cracked. Structures subjected to freezing and thawing have disintegrated. Concrete homes are cold and damp. Sewer pipe and drain tile are attacked by acids and alkalis. Thin dams leak."

It is encouraging to report substantial activity on both of these fronts.

Of primary importance in the field of bituminous pavements is the necessary thickness of flexible type surfaces. After many years of guess work scientific methods of design are beginning to emerge from research going forward in several places. The National Crushed Stone Association laboratory is taking a leading part in this work and Mr. Goldbeck's recent reports are receiving widespread attention. He can do a great service by the continuation of his experiments.

At last there is prospect of concerted and adequate attack on the exceedingly complicated problem of the factors that effect the durability of portland cement concrete. For one thing, a joint research project on durability of concrete has recently been organized by the American Concrete Institute, the American Society for Testing Materials and the Highway Research Board. It is expected through this cooperative effort to formulate a comprehensive research program and enlist the services of a large number of research agencies in doing the work. Mr. Goldbeck is a member of the administrative committee in charge of this joint effort of three national organizations.

Recently the Portland Cement Association has announced the start of a long time study of the performance of cement in concrete. This program will involve construction under close control and observation over a period of years of 90,000 sq. yd. (about 8 miles) of concrete pavement and 2,500 cu. yd. of concrete in miscellaneous structures.

No, we are not through yet, and probably never will be. Some of the factors needing investigation have already been studied for a long time, and conditions of use seem to change so often that we never quite catch up. For instance the gradation of mineral aggregates has been studied at least since Roman times, and yet I find it first on my list of needed research items.

Likewise we still need investigation of the effects and control of flat and elongated particles, and surface coatings.

The factors that affect durability of both cement concrete and bituminous mixtures are little understood and perhaps constitute the greatest need for research attack at this time. What is the relation to durability of the thermal expansion of stone particles, of roughness, absorptive properties, hardness, and of unsoundness?

Investigation of the factors that influence the adhesion of bitumen to rock particles is by no means complete, and I am sure this is a matter of great importance to the industry.

Neither has the last word been said on the proportioning of concrete. We still depend to considerable extent on cut and try methods. I have long thought that sooner or later we should learn enough to be able to take samples of the cement and aggregates to be used, measure and determine their significant properties and from these data compute mixes which will give the desired workability, strength and life.

I feel that I have been pounding at a straw man in arguing the value of research to this audience. The record of the crushed stone industry is too well known for me to doubt that the industry as a whole is completely sold on these activities.

But I wonder if we realize the vital importance of research in the vastly greater sphere of our national life. Do we realize that research of all kinds is essential to the continued security of this nation? History teaches us that when older civilizations ceased to progress, ceased to enhance productivity they started down and ultimately passed away, leaving only some ruins to testify to the attainments of their research men. It must have been a nice problem to study out how to build the great Egyptian and Mayan pyramids with the available mechanical forces of those days.

To paraphrase a much quoted slogan of the day,—if to be free we must be strong and if to be strong we must be productive, then to be productive we must study and delve for new facts, and learn to apply them as never before.

Two States to Modernize Defense Roads

CONNECTICUT and West Virginia are laying plans for modernization of defense highways. Connecticut plans call for widening of shoulders on 245 miles of roads at a cost of $2,230,000, of which $1,130,000 is expected to be furnished by the Federal Government. West Virginia expects to construct a system of parking lanes for modernized military trains along some 350 miles of roads.

Are We Progressing Fast Enough in the Defense Effort[1]

By STACY MAY

Chief, Bureau of Research and Statistics, Office of Production Management

• The first year of our defense effort has recently been concluded. The extent to which this effort has been successful is of vital concern to every citizen of the nation. In the following article Mr. May gives us a realistic picture of the current status of the defense effort.

I HAVE been asked to report to you upon the topic, "Are we progressing fast enough?" The answer, flatly, is "no." But since one syllable answers are apt to conceal as much truth as they reveal, and, since we now have reached the end of the first year of our defense effort, it is fitting that the people of the United States should have an explanation of why a negative answer must be given.

It is part of my responsibility to report to the Office of Production Management the progress that is being made in the defense effort. Our reports to OPM deal in intricate detail with requirements, contracts and deliveries for specific military items and their components—contract by contract, plane by plane, ship by ship, and gun by gun. Much of this detail may not be made public, and in any case it is easy to get lost in a welter of figures. So I shall report to you upon the program as a whole rather than in detail.

There are, as I see it, three relevant measures of whether or not our progress to date is adequate: (1) Are we making satisfactory progress, are deliveries coming through promptly upon the program that has been adopted to date? (2) Does the enacted program represent the mobilization of a fair share of our total economic resources when measured against the efforts being put forth by nations who have a comparable stake in the outcome of the war? (3) Is our planned effort great enough in absolute terms? Is it great enough to make certain that the Axis powers will go down to ultimate defeat?

I shall try to present to you the evidence which forces the answer "no" to each of these three questions. You will understand, of course, that no one connected with an effort, upon the outcome of which so much is at stake, could ever express anything but discontent with the accomplishment at a given date. The gravity of this unlimited emergency calls for far more than our best effort. However, I shall try to sift from my answers as much as I can of emotional impatience and present to you the verdict of objective facts.

First then, what is the magnitude of the program we have undertaken? Our defense effort in 1940, in terms of actual deliveries of defense material, was meager by any objective measurement that can be applied. We did not get under way upon a serious productive effort until last June, and during the remainder of the year 1940 we succeeded in spending only a little over $4 billion for defense items. And this includes expenditures of England and France in this country as well as our own. We did, however, develop plans for a greatly expanded effort. These plans at present call for defense expenditures in this country of over $40 billion during the calendar years 1941 and 1942. To live up to this program we must spend for defense something over $17 billion during 1941 and well over $23 billion in 1942.

Where are we at present in the fulfillment of these schedules? The record of funds actually spent does not show satisfactory accomplishment. In some cases we make prepayments for work that is not completed, while in others payments are delayed upon deliveries actually made or on plants and facilities actually in place. But for all that, expenditures are the best over-all single index of progress that we have. During the first four months of 1941, through April 30, defense expenditures in the United States totalled $3,700 million. The monthly rate of expenditure, however, was stepping up sharply, and April expenditures were $1,100 million or at the rate of $13 billion a year. In order to achieve the program we have set expenditures must continue to step up at an accelerated pace. If we are to achieve the $17 billion program set for this year, expenditures for the second four months of the year must average $1,500 million a month and for the last four months something like $2 billion a month. The latter rate must be maintained through 1942 if we are

[1] Address over Station WOL, Washington, and the Mutual Broadcasting System, on Sunday, June 1, as part of Northwestern University's program, "The Reviewing Stand."

to meet the goal that we have set for ourselves next year.

The task of meeting this year's load is a formidable one, and it will require greater effort and greater sacrifice than has been put forth to date. It is absolutely essential that this effort be made. Unless we meet our 1941 schedules, it will be extremely difficult for us to meet those of 1942. For into the 1941 schedules we have loaded $4 billion worth of new plants and facilities for producing armaments. These are essential for our production of armament material. Yet no shooting can be done with an industrial facility. The 1942 schedules of actual armament items represent a doubling of those that we can expect to produce in the current year.

To date, then, the record shows that we have not been moving fast enough upon our established schedules. We have put an impressive amount of energy into the effort, but we have tried to meet our armament loads by placing them on top of the normal "business-as-usual" procedure. We have tried to obtain our armament production to a considerable extent through plants manned with completely new machines fabricated for the purpose. We have been too timid in diverting machines that might be used for armament production from the civilian work upon which they have been engaged. It is not unfair to say, I think, that to a great extent we have kept our best managerial skill, our best machinery and our most highly skilled labor upon civilian production. Defense has had to depend upon newly improvised factory units, the *surplus* energy and imagination of our finest management groups, who still were occupied with their regular responsibilities, and upon labor forces recruited largely from the ranks of the unemployed. On the other hand, we have, I think, been unduly timid in planning for expansions in the raw material fields. Here it is essential that we expand if in the near future we are to undertake military production far larger than that envisaged to date without calling for civilian sacrifices that are unduly great and unjustified because they might have been made unnecessary.

On our present program, then, the record shows that we are not proceeding fast enough. It is the responsibility of Government, of business, and of labor, to see that there is no failure in the scheduled accomplishment of what we have undertaken.

The second basis of measurement is the question whether we are devoting a sufficient proportion of our resources to defense. Are we doing as much as we can do?

Certainly the strong may be expected to do more than the weak, the rich to give more than the poor. Measured in terms of the proportion of total productive capacity devoted to war effort, are we doing as much as England or Canada, or Germany, or Italy, or Japan? Again, the answer is "no." The $4.2 billion we spent on defense in 1940 represented less than 6 per cent of our national income. That is the dimension of an interest payment—a token rather than a delivery upon our debt to the world issue. The $17 billion we are scheduled to spend in 1941 will represent only 20 per cent of this year's national income. It is dangerous to make predictions for 1942, but it is safe, I think, to say that an expenditure of $23 billion next year will represent less than 25 per cent of the national income.

What are other nations doing? Canada spent on war effort over 20 per cent of her national income in the fiscal year ending last March and plans to double this proportion in the next fiscal year. Great Britain in the coming year will channel over 40 per cent of her national income into war effort, Germany according to the best reports we can get, is devoting an even greater percentage of her income to war expenditures. Italy seems to be marshalling at least 25 per cent of her resources for war purposes, and Japan probably has earmarked about 30 per cent of hers. Why should we on a comparative basis be putting forth an effort only half, or less than half, of that being made by Canada, by England, and by Germany? In many ways we are equipped to make a greater effort than theirs with less sacrifice. First, we start with a higher standard of living. Hence we may cut further into it before reaching the irreducible lower limit. Second, a greater proportion of our peace-time industry was devoted to the production of durable goods from which a transfer may be made to armaments with least serious dislocation. Either we mean to do a job or we don't mean to, in any serious fashion. If we do, it behooves us to face the dimension of that job squarely and to do what is necessary.

That brings me to the third measure of the adequacy of our effort: what is the job that needs to be done? How much must we do in order that we may be assured that Germany's attempt at world domination will meet defeat. Here accurate measurement is more difficult; but I think that it is not impracticable to define our task in broad dimension. First, let me say this, if we are to be certain of reaching our goal, the British Empire and the United States must not only achieve current production larger than that of the Axis and their tributary

lated military reserves substantially larger than those which will result from our scheduled production plans for 1941 and 1942 combined. Since then she has seized formidable stores of military equipment from the countries which she has conquered. There seems to be little doubt that she will produce in 1941 and 1942 substantially more military equipment than is called for in our present plans for the United States.

But the most important comparison, of course, is the total armament production of the Axis powers against that of the British Empire and the United States combined. Let us look at these estimates in broad totals. During 1941 we are scheduled to spend $17 billion, Great Britain something like $15 billion, the rest of the British Empire perhaps $5 billion—total $37 billion—for defense and war. In 1941 Germany will spend the equivalent of $20 to $25 billion upon arms. We do not know how much she is able to extract by forced draft from occupied areas, but certainly the higher figure of $25 billion is conservative if the latter be included. Italy's war expenditures may amount to $2 billion and Japan's to $3.5 billion. Thus the Axis expenditures will total at least $30 billion.

The picture is not wholly gloomy. Unless the Axis productions are greatly under-estimated—and they may well be—Britain and the United States together will have a current margin of productive superiority providing our contribution will be delivered safely where it can be put to effective use. Whatever margin there may be, it is too slight to overcome within any reasonable time the initial advantage of armament superiority Germany had built up before we started.

It is clear that we must move faster. This, so far as we may learn from the experience to date, is a war of equipment and materiel rather than of brute manpower. If we were to double our load for defense, if we were to develop an intelligent armament program calling for $40 billion worth of production *a year,* the balance of superiority would be clear and the time when it would be achieved sufficiently close to make the defeat of the Axis powers certain. If we were to achieve an annual $40 billion armament program, we should be doing in proportion to our strength no more than Canada or England or Germany are doing now.

In view of President Roosevelt's declaration of our national purpose, the question is whether we can justify doing less.

These are my reasons for believing that we are not at present progressing fast enough.

Cincinnati Selected for Convention

(*Continued from page 3*)

and the National Ready-Mix Concrete Association will be held at the Netherland Plaza Hotel in Cincinnati, on January 28, 29, and 30, thus continuing the cooperative policy of scheduling these conventions during the week preceding that of the National Crushed Stone Association convention as a matter of convenience and economy to the many exhibitors who participate in the expositions held by these groups.

It was the belief of the Executive Committee that unusual care should be exercised in planning the Silver Anniversary Convention and to this end President Rigg appointed a sub-committee of the Executive Committee to undertake this important responsibility. This sub-committee, consisting of Messrs. Otho M. Graves, Chairman, Russell Rarey, Stirling Tomkins, A. L. Worthen, and J. R. Boyd, will submit a report to the mid-year meeting of the Board at Hot Springs, Virginia, on July 10.

It will thus be seen that plans are well under way for making the Silver Anniversary Convention an occasion which should long stand out as a most enjoyable and inspirational affair. All interested, directly or indirectly and whether or not members of the National Crushed Stone Association, are most cordially invited to attend.

Russian Farmers Build Road Over "Roof of the World"

RUSSIAN farmers have just completed an important road across the Pamir Mountains, a route that will open up immense natural resources. This road over the so-called "Roof of the world" is 352 miles long and was built in 100 days by 22,000 collective farmers of the Soviet Republic. It crosses turbulent rivers, inaccessible gorges, and was literally blasted in some places through solid rock. It reaches an altitude of over two miles above sea level in one pass. Perhaps the most interesting feature, however, is the fact that the building of the road was started on the farmers' own initiative. They felt that the lack of a road was a hinderance to their economic and cultural development. Formerly supplies into this central Asian district could only be transported in the short summer of three months and then only by camels and horses. Now motor vehicles will traverse the new highway throughout the year.

A Rational Approach to the Secondary Road Problem

(*Continued from page 10*)

PROJECT—ORAVILLE ROAD, ST. MARYS COUNTY

% Passing Screen Size as Indicated	1"	½"	10	40	200
Original Mixture Design ------ Plasticity Index 13.0 Liquid Limit 31.2	100	98	64	44	17.3
Analysis of 4/8/41 ---------- Plasticity Index 11.5 Liquid Limit 24.7	100	99	66	43	13.9

PROJECT—CHAPEL ROAD, HARFORD COUNTY

% Passing Screen Size as Indicated	1"	½"	10	40	200
Original Mixture Design ------ Plasticity Index 4.3 Liquid Limit 22.3	92	78	53	37.1	20.1
Analysis of 4/8/41 ---------- Plasticity Index 5.1 Liquid Limit 20.4	92	80	56	38.9	18.6

Shoulder Stabilization

Maintenance of shoulders along high-type pavements has always presented a problem, where the soil is of such nature as to soften easily and become unstable in wet weather. Even when bituminous covers are provided, heavy vehicles cause a settlement of the unstable base material and the shoulders soon drop down to a level lower than the roadway. We have found that chemical stabilization of shoulders prior to bituminous surfacing is a practical and economical method of eliminating this traffic hazard and reducing maintenance to a minimum.

The effectiveness of the chemical treatment in attaining densities necessary to stability was forcibly brought home to us in the case of shoulder work performed during 1938 and 1939 on Maryland Route No. 2 between Baltimore and Annapolis. This route, known as the Governor Ritchie Highway, is a 4-lane divided highway and, during peak seasons, carries as high as 15,000 vehicles a day.

Along both sides of this 26-mile highway, we placed a graded soil-aggregate mixture, 6 inches in depth and 8 feet in width. In approximately 70 per cent of this shoulder construction, the surface was treated with calcium chloride, while the balance was left untreated. Then bituminous prime and seal coats were applied. Careful inspection in March of this year revealed not a single sign of failure where the base had been chemically treated; whereas the remaining 30 per cent has required almost constant maintenance and shows it. The base material for both sections were taken from the same pit, were of exactly the same gradation, and identical construction methods were followed.

Highways Keep Defense Goods Moving

THE nation's great effort to supply and arm men in the field, often termed the "Battle of Production," is being waged with sweat and ingenuity, with men and machines, and with transportation.

In every industrial scene, transportation is the taken-for-granted agent that links each step of production to its neighbor. Side by side with rail and water transportation, motor trucks are doing their part.

Over the highways roll the motor trucks, keeping goods in movement, providing a flexible and nation-wide conveyor system.

It's an increasingly heavy load for trucks now that interplant movement is gaining momentum and extra-schedule emergency operations are becoming commonplace. One Midwestern aviation parts supplier whose plant is served by 100 trucks a day, expects an even higher rate of truck movement in coming months.

A Buffalo airplane plant is building fuselages at its old plant and transporting them by truck to a new plant for final assembly into complete planes.

Of all incoming freight, 90 per cent received by the above aviation plant is by truck, with a higher percentage anticipated in the next six months. Scores of firms working on defense orders—steel mills, heavy machinery manufacturers, meat packers, ordnance firms, mining concerns—report that they anticipate trucks will handle a high percentage of total shipments before the year is far advanced.

Between the first of the year and mid-April, nearly 22 per cent of all production in motor truck plants was for military purposes and 14 per cent additional was for civilian projects specifically connected with defense.

One truck producer recently reported that 80 per cent of the plant's machine hours will be absorbed by military needs and that production of the remaining 20 per cent would be virtually reserved to customers having a priority rating for defense.

Transportation is not all freight. To win the "Battle of Production" men are needed—at the machine, on the assembly line, and at the loading dock to keep the movement of goods going. Here the private automobile fits into the essential transportation pattern. For just as failure of an essential part to arrive on time at the assembly line would halt the flow of vital goods, so work would stop if men failed to arrive when needed. So the flow of cars over the highways today becomes a step in production.

Inside the factory walls the key to the thousands of processes that interlock perfectly at every point is transportation, although it is hardly ever thought of in those terms.

The visitor sees tons of material coming from somewhere, going somewhere else, hand-trucks scooting along, overhead conveyors and moving roller platforms carrying an endless stream of half-finished pieces. This activity may look bewildering, but it is the functioning of an orderly system of factory transportation.

Whether the product being made is an armored tank or "ack-ack" gun or altimeter instrument, transportation forms the one continuing link as the product takes definite shape, moving from machine to machine, as it passes from craftsman to machinist to assembler, as it comes under the scrutiny of inspector and tester and shipping superintendent.

Sometimes a finished article is produced in a single plant. More often a product is packed and shipped to another plant, there to be assembled as one unit in its final form, whether submarine engine, machine gun, aircraft fuselage.

Transportation sometimes welds two assembly lines together, even though the lines are miles apart. As soon as his vehicles can roll under their own power, a Cleveland manufacturer drives his military trucks 51 miles to Canton, Ohio, to be fitted with armored bodies, then drives the complete unit back. In that way, his products furnish their own transportation, and relieve the shipping load to that extent upon hard-pressed public transportation facilities.

In the Lake Superior ore fields, the reopening of unused pits has resulted in the increased use of trucks.

Motor Vehicle Registration Shows Sharp Increase

THE third largest annual increase in registrations of motor vehicles since the depression occurred in 1940, the Public Roads Administration of the Federal Works Agency announced recently.

Motor-vehicle registrations last year surpassed the 1939 figure by 1,442,991. This compares with an increase of 1,950,027 in 1936 and 1,576,474 in 1937. The all-time record increase was 2,850,000 in 1923.

In the past 42 years in which motor vehicles have been registered, the only decreases were recorded in 1938 and in each of the three years, 1931-33.

Last year 32,452,861 motor vehicles were registered according to reports of State authorities to the Public Roads Administration. Registration fees amounted to $373,771,000. Miscellaneous receipts, such as fees for permits and certificates of title, fines, and penalties, brought total receipts in 1940 to $439,178,000, or $26,684,000 more than in 1939.

Forty-four States and the District of Columbia took in $29,898,000 in fees for driver permits.

The 1940 registrations included 32,025,365 private and commercial vehicles; 143,175 vehicles owned by the Federal Government; and 284,321 owned by State, county, and municipal governments.

Motor Truck Transportation Problems in Defense Will Be Studied

THE creation of a Central Motor Truck Committee with 16 regional committees to study motor truck transportation problems and to advise government officials was announced June 25 by Ralph Budd, Transportation Commissioner, Office for Emergency Management.

John Rogers, Interstate Commerce Commissioner, was named Chairman of the Central Committee and H. H. Kelley, Safety Chief of the Bureau of Motor Carriers of the Interstate Commerce Commission, will serve as Secretary. Field directors of the Motor Carrier Division of the I. C. C. will serve as chairmen of the 16 regional committees and regional headquarters will be in the I. C. C. field directors' offices.

Priority in motor truck production will be one of the immediate problems facing the central and regional truck committees. A survey of the motor truck industry and a motor truck census are now in progress. Data concerning trucks and truck operators will be studied initially by the regional committees to determine whether a shortage of trucks exists. Although not stated in the Transportation Commissioner's announcement, it is expected the committees will make close study of possible duplication of truck services and give consideration to consolidation of deliveries.

Upon the findings of such studies, the committees are expected to base recommendations for priorities on types of trucks to be manufactured and to what industries they will be made available, as well as other recommendations relating to highway transportation problems.

MANUFACTURERS' DIVISION

of the

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These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.

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The Buda Company
Harvey, Ill.
Buda-Lanova Diesel Engines, Buda Gasoline Engines, Buda Lifting Jacks from 1½ to 100 tons, Buda-Hubron Earth Drill, Buda Railway Equipment and Supplies

Cross Engineering Co.
Carbondale, Pa.
Screen Plates and Sections, Perforated Plate, for Vibrating, Rotary and Shaking Screens

Deister Machine Company
1933 East Wayne Street, Fort Wayne, Ind.
Deister Plat-O Vibrating Screen, Deister Compound Funnel Classifier

Diamond Iron Works, Inc.
Minneapolis, Minn.
Rock Crushing, Conveying and Transmission Machinery

E. I. du Pont de Nemours & Co., Inc.
Wilmington, Del.
Explosives and Blasting Accessories

Easton Car and Construction Co.
Easton, Pa.
Quarry Cars, Truck Bodies and Trailers Electric Heaters for Tar, Asphalt or Bitumen

MANUFACTURERS' DIVISION of the NATIONAL CRUSHED STONE ASSOCIATION

Ensign-Bickford Co.
Simsbury, Conn.
Cordeau-Bickford Detonating Fuse and Safety Fuse

Frog, Switch & Mfg. Co.
Carlisle, Pa.
Manganese Steel Department—Manufacturers of "Indian Brand" Manganese Steel Castings for Frogs, Switches and Crossings, Jaw and Gyratory Crushers, Cement Mill, Mining Machinery, etc., Steam Shovel Parts

General Electric Co.
1 River Road, Schenectady, N. Y.
Electric Motors

General Motors Sales Corporation, Diesel Engine Division
13400 Outer Drive, Detroit, Mich.
Diesel Engine Equipment for Portable Electric Generator Sets, Direct Drive Power Units, Replacement Truck Engines, and Power Units for Haulage Equipment.

Goodyear Tire & Rubber Co.
Akron, Ohio
Belting (Conveyor, Elevator, Transmission), Hose (Air, Water, Steam, Suction, Miscellaneous), Chute Lining (Rubber)

Gruendler Crusher and Pulverizer Co.
2915 N. Market St., St. Louis, Mo.
Rock and Gravel Crushing and Screening Plants, Jaw Crushers, Roll Crushers, Hammer Mills, Lime Pulverizers

Hardinge Co., Inc.
York, Pa.
Scrubbers, Pulverizers, Dryers, Feeders, Classifiers, Washers, Thickeners

HarriSteel Products Co.
420 Lexington Avenue, New York, N. Y.
Woven Wire Screen Cloth and Abrasion Resisting Products

Hayward Co.
50 Church Street, New York City
Orange Peel Buckets, Clam Shell Buckets, Drag Line Buckets, Electric Motor Buckets, Automatic Take-up Reels

Hendrick Mfg. Co.
Carbondale, Pa.
Perforated Metal Screens, Perforated Plates for Vibrating and Shaking Screens, Elevator Buckets, Hendrick Vibrating Screens

Hercules Powder Co.
Wilmington, Del.
Explosives and Blasting Supplies

Illinois Powder Mfg. Co.
124 N. 4th St., St. Louis, Mo.
Gold Medal Explosives

Iowa Manufacturing Co.
Cedar Rapids, Iowa
Rock and Gravel Crushing, Screening, Conveying and Washing Plants, Hot and Cold Mix Asphalt Plants, Stabilizer Plants, KU-BIT Impact Breakers, Screens, Elevators, Conveyors, Portable and Stationary Equipment.

Kennedy-Van Saun Mfg. and Eng. Corp.
2 Park Ave., New York City
Material Handling Machinery—Crushers, Pulverizers, Vibrating Screens

Kensington Steel Co.
505 Kensington Ave., Chicago, Ill.
Manganese Steel Castings, Dipper Teeth, Crawler Treads, Jaw Plates, Concaves and Hammers

The King Powder Co., Inc.
Cincinnati, Ohio

Koehring Co.
3026 W. Concordia Ave., Milwaukee, Wis.
Mixers, Pavers, Shovels, Cranes, Draglines, Dumptors, Traildumps, Mud-Jacks

Kraft Bag Corporation
630 Fifth Ave., New York City
Multi-Wall and Heavy-Duty Paper Sacks, both Valve and Openmouth

Lima Locomotive Works, Inc.
Shovel and Crane Division
1108 Lima Trust Bldg., Lima, Ohio
Power Shovels, Draglines and Cranes

Link-Belt Co.
300 West Pershing Road, Chicago, Ill.
Complete Stone Preparation Plants. Conveyors, Elevators, Screens, Washing Equipment, Speed-o-Matic Shovels—Cranes—Draglines and Power Transmission Equipment

Ludlow-Saylor Wire Co.
Newstead Ave. & Wabash R. R., St. Louis, Mo.
Woven Wire Screens and Wire Cloth of Super-Loy, Manga-Loy and all commercial alloys and metals

Marion Steam Shovel Co.
Marion, Ohio
A Complete Line of Power Shovels, Draglines and Cranes

MANUFACTURERS' DIVISION of the NATIONAL CRUSHED STONE ASSOCIATION

McLanahan & Stone Corp.
Hollidaysburg, Pa.

The National Supply Co. of Delaware, Superior Engine Division
1401 Sheridan Ave., Springfield, Ohio
Diesel Engine Equipment

Nordberg Mfg. Co.
Milwaukee, Wis.
Cone Crushers, Vibrating Screens, Diesel Engines, Steam Engines, Compressors, Mine Hoists, Underground Shovels, Track Maintenance Tools

Northern Blower Co.
65th St. South of Denison, Cleveland, Ohio
Dust Collecting Systems, Fans—Exhaust and Blowers

Northwest Engineering Co.
28 E. Jackson Blvd., Chicago, Ill.

The Osgood Company
Marion, Ohio
Power Shovels, Draglines, Cranes

Parsons Engineering Corp.
3599 E. 82d St., Cleveland, Ohio
Dust Collecting Systems: Fans, Hoods and Blow Piping

Pioneer Engineering Works, Inc.
1515 Central Avenue, Minneapolis, Minn.
Jaw and Roll Crushers, Vibrating and Revolving Screens, Scrubbers, Belt Conveyors, Traveling Grizzley Feeder

Pit and Quarry Publications
538 South Clark St., Chicago, Ill.
Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Manufacturer, Concrete Industries Yearbook

Robins Conveying Belt Co.
Passaic, N. J.
Belt Conveyors, Bucket Elevators, Gyrex and Vibrex Screens, Feeders, Design and Construction of Complete Plants

Rock Products
309 West Jackson Blvd., Chicago, Ill.

Ross Screen and Feeder Co.
19 Rector St., New York City
Ross Patent Chain Feeders for Feed Control of All Sizes Rock, Ores, Gravel, etc.

Screen Equipment Co.
9 Lafayette Ave., Buffalo, N. Y.
SECO Vibrating Screens

Simplicity Engineering Co.
Durand, Mich.
Simplicity Gyrating Screen, Simplicity D'centegrator, Simplicity D'watering Wheel

Smith Engineering Works
E. Capitol Drive at N. Holton Ave.,
Milwaukee, Wis.
Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Stephens-Adamson Mfg. Co.
Aurora, Illinois
Complete Stone Preparation Plants, Conveying, Elevating, Screening, Transmission Equipment

W. O. & M. W. Talcott, Inc.
91 Sabin St., Providence, R. I.
Belt Fasteners, Belt Lacing, Conveyor Belt Fasteners, and Patch Fasteners

Taylor-Wharton Iron & Steel Co.
High Bridge, N. J.
Manganese and other Special Alloy Steel Castings

The Texas Co.
135 E. 42nd St., New York City

The Thew Shovel Co.
Lorain, Ohio
Power Shovels, Cranes, Crawler Cranes, Locomotive Cranes, Draglines. Diesel Electric, Gasoline. 3/8 to 2-1/2 cu. yd. capacities

The Traylor Engineering & Mfg. Co.
Allentown, Pa.
Stone Crushing, Gravel, Lime and Cement Machinery

Trojan Powder Co.
17 N. 7th St., Allentown, Pa.
Explosives and Blasting Supplies

The W. S. Tyler Co.
3615 Superior Ave., N. E., Cleveland, Ohio
Wire Screens, Screening Machinery, Scrubbers, Testing Sieves and Dryers

Warren Brothers Roads Co.
38 Memorial Drive, Cambridge, Mass.
Complete plants and separate plant units for bituminizing all types of stone, sand and gravel aggregate paving mixtures

Westinghouse Electric & Mfg. Co.
East Pittsburgh, Pa.
Electric Motors and Control